National Aeronautics and Space Administration

Electron Beam Freeform Fabrication (EBF^3) Technology for Additive Manufacturing of Metal Parts

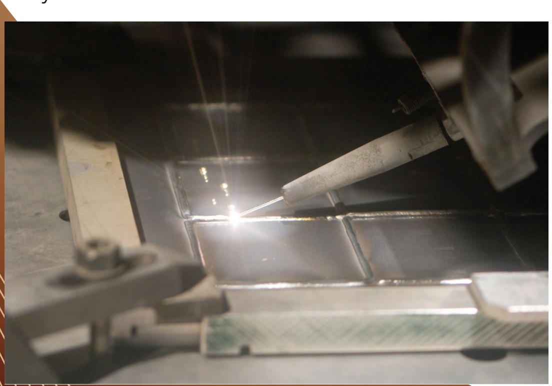
Cost-effective manufacturing of near-net-shape metallic components using less time, less energy, and less raw materials.

TECHNOLOGY OPPORTUNITY

NASA Langley Center has developed an additive manufacturing process for building near-net-shape metal parts directly from CAD geometry without molds or tooling. EBF^3 is a scalable, cost-effective replacement for traditional forging and machining to produce metallic parts and for on-demand repair or fabrication of replacement parts. EBF^3 can be considered a "green manufacturing" technology in that it produces parts equivalent to those fabricated via conventional machining processes but uses less time, less energy and less raw materials. The process is ideal for custom fabrication, low production runs and prototypes.

BENEFITS

- Scalability – EBF^3 is capable of producing parts at higher deposition rates across a much larger size range than competing laser and electron beam systems using powders.
- Transfer Efficiency and Handling – Wire feedstock for EBF^3 is far easier to handle and does not have pyrophoric or explosion hazards associated with metal powder. 100% of the wire is captured in the part, with 10–15% material removal required for finish machining to final geometry.
- Energy Efficiency – Electron beams are extremely efficient energy sources, with up to 90% of the energy used by the system output in the electron beam.
- Geometric Flexibility – The EBF^3 process can build parts with overhangs, undercuts and embedded geometric features that are very difficult to machine.
- System Utility – The EBF^3 process operates in a modified pre-existing electron beam welding system.



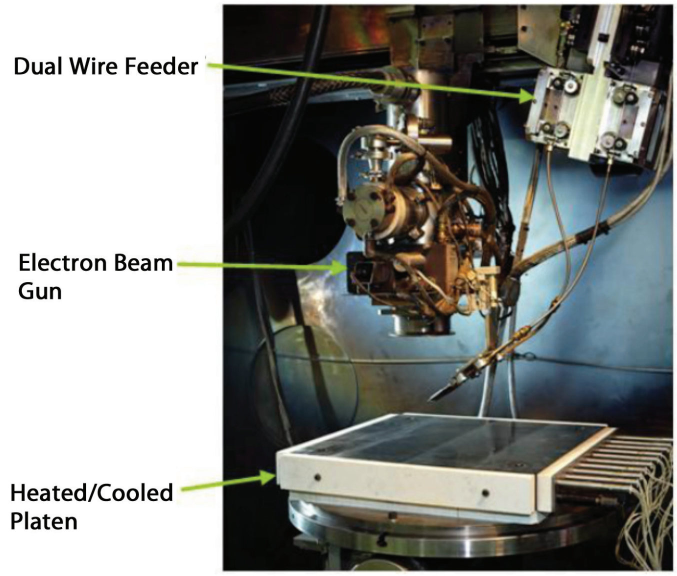
APPLICATIONS

The technology offers wide-ranging market applications, including:

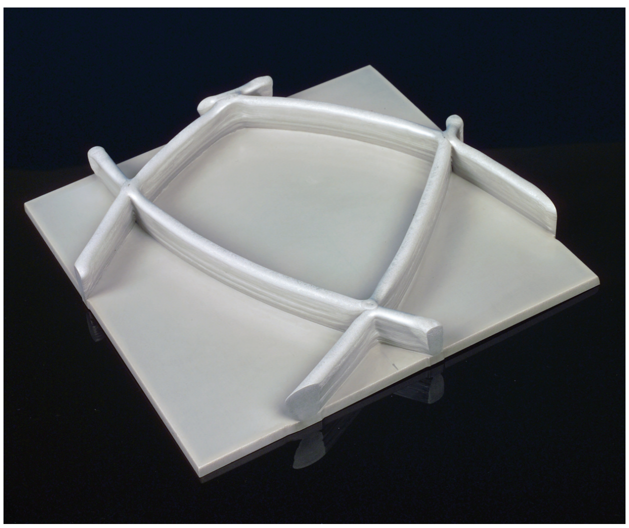
- Fabrication or repair of tooling and dies for high volume part production (such as molds for plastic or metal forming used in the automotive industry)
- Aircraft components (wing/fuselage stiffened structures, pressure vessels, bulkheads, spars, ribs, engine cases)
- Support of electrical power generation and other systems requiring high availability
- Launch vehicle structures (isogrid/orthogrid stiffened structures including pressurized, cryogenic fuel tanks)
- Custom manufacturing industries (custom-built motorcycle and automobile components, out-of-production parts for vehicles or heavy machinery)
- Prototype components (first-run concept vehicle demonstrators, functional wind tunnel test models)
- Medical implant devices (load-bearing hip or bone implants tailored for the patient)
- Fabrication or repair of oil and gas drilling bits and hardware
- On-demand repair or replacement parts for Navy submarines and ships in service, field-deployed Army combat units, remote scientific bases
- Space-based manufacturing (build in space for use in space, fabrication of large space structures otherwise impossible to launch from Earth)

TECHNOLOGY DESCRIPTION

Current computer-aided machining practices start with a solid CAD model and use a post-processor to write the machining instructions (such as G-code) defining the cutting tool paths needed to make the part. EBF^3 uses a similar process, starting with a CAD model, slicing it into layers, and then using a post-processor to write the code defining the deposition path and process parameters for the EBF^3 equipment. The EBF^3 process uses a focused electron beam in a vacuum environment to create a molten pool on a metallic substrate (Figure 1). The beam is translated with respect to the surface of the substrate while metal wire is fed into the molten pool. The deposit solidifies immediately after the electron beam has passed, having sufficient structural strength to support itself. Careful attention to the process design is still required to minimize deformation until the part cools. A part is thus built directly from a CAD file in a layer-additive fashion without molds or tooling dies. The electron beam can be precisely steered to control the size of the molten pool and facilitate capture of the wire. The wire is preheated by the beam but is not melted until it enters the molten pool.



The EBF^3 system.



FOR MORE INFORMATION

If your company is interested in licensing or joint development opportunities associated with this technology, or if you would like additional information on partnering with NASA, please contact:

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